MycoKeys 76: 31–47 (2020)
doi: 10.3897/mycokeys.76.58179
https://mycokeys.pensoft.net

RESEARCH ARTICLE

A peer-reviewed open-access journal
MycoKeys
Launched to accelerate biodiversity research

New *Cantharellus* species from South Korea

Bart Buyck[1], Valérie Hofstetter[2], Rhim Ryoo[3], Kang-Hyeon Ka[3], Vladimír Antonín[4]

1 *Institut de Systématique, Écologie, Biodiversité (ISYEB), Muséum national d'histoire naturelle, CNRS, Sorbonne Université, EPHE, 57 rue Cuvier, CP 39, F-75005, Paris, France* **2** *Département fédéral de l'économie, de la formation et de la recherche DEFR, Agroscope Domaine de recherche Protection des végétaux, Route de Duillier 60, CP 1012, 1260, Nyon 1, Switzerland* **3** *Department of Forest Bioresources, National Institute of Forest Science, Suwon 16631, South Korea* **4** *Department of Botany, Moravian Museum, Zelný trh 6, CZ-659 37, Brno, Czech Republic*

Corresponding author: Vladimír Antonín (vantonin@mzm.cz)

Academic editor: B-K Cui | Received 31 August 2020 | Accepted 24 November 2020 | Published 22 December 2020

Citation: Buyck B, Hofstetter V, Ryoo R, Ka K-H, Antonín V (2020) New *Cantharellus* species from South Korea. MycoKeys 76: 31–47. https://doi.org/10.3897/mycokeys.76.58179

Abstract

In this third contribution involving new *Cantharellus* species from South Korea, two new species are introduced. In addition, we document a first report of the recently described Japanese *Cantharellus anzutake* outside of Japan based on identical ITS sequence data. *Cantharellus citrinus* **sp. nov.** is introduced as a new member of subg. *Cinnabarini*, to which the closely related Korean *C. albovenosus* and Chinese *C. phloginus* also belong. *Cantharellus curvatus* **sp. nov.** is introduced as a new member of subg. *Parvocantharellus*, in which the Korean *C. koreanus* was recently placed. The respective placements of the new taxa are significantly supported by a phylogenetic analysis of sequences from the transcription elongation factor (*tef*-1).

Keywords

ITS, morphology, new species, phylogeny, *tef*-1

Introduction

In our previous contributions reporting the biodiversity of *Cantharellus* Adans.:Fr. in Korea (Antonín et al. 2017; Buyck et al. 2018), we have reviewed the still limited taxonomic knowledge on *Cantharellus* species in Asia. During the past two years two more new chanterelles have been described from Asia: *C. anzutake* W. Ogawa, N. Endo, M. Fukuda and A. Yamada from Japan (Ogawa et al. 2018) and *C. hainanensis* N.K. Zeng, Zhi Q. Liang & S. Jiang from China (An et al. 2017). In the present paper, we

Copyright *Bart Buyck et al.* This is an open access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

describe two more new species from South Korea supported by morphological features and in particular by sequence data obtained for the transcription elongation factor (*tef*-1) gene. In addition, identical ITS sequence data also document the presence, in South Korea, of the recently described *C. anzutake* from Japan, a species belonging to subg. *Cantharellus* and based on a 100 base pair deletion in the internal transcribed spacer 1 (ITS1) of the rDNA (Ogawa et al. 2018). Obtained *tef*-1 sequence data from all of our recent collections of chanterelles in South Korea could not confirm the presence of any of the European or North American *Cantharellus* previously reported from South Korea (Park and Lee 1991; Kim 2004; Kim et al. 2006; Lee 2011) nor any of the chanterelles already described from India (Das et al. 2015; Kumari et al. 2011, 2013), neighbouring China (Shao et al. 2011, 2014, 2016a, b; Tian et al. 2012; An et al. 2017), Japan (Suhara and Kurogi 2015; Ogawa et al. 2018) or Malaysia (Corner 1966; Eyssartier et al. 2009)

Materials and methods

Field work

Collections for this work were made during field trips of the last author in collaboration with colleagues from the National Institute of Forest Science (former Korea Forest Research Institute) in the margin of two larger inventory projects: "Diversity and molecular taxonomy of marasmielloid and gymnopoid fungi (Basidiomycota, Omphalotaceae) in South Korea" and "Phylogeny of litter decomposing fungi in South Korea". The various localities in which *Cantharellus* specimens were collected are shown below (Fig. 1).

Morphology

Macroscopic descriptions of collected specimens were based on fresh basidiomata. Colour abbreviations follow Kornerup and Wanscher (1983). Microscopic features were studied using dried material mounted in H_2O, approximately 5% KOH, Melzer's reagent and Congo Red, using an Olympus BX-50 light microscope (Tokyo, Japan) at 1000× magnification. For the hymenophore, "L" refers to the number of whole gill folds, while "l" refers to the number of shorter gill folds between each pair of entire gill folds. For basidiospores, the factor E indicates the quotient of the length and width in any one basidiospore and Q is the mean of the E-values; the basidiospore values are based on 20 measurements in each collection. Specimens are preserved in the herbarium of the Moravian Museum, Brno, Czech Republic (**BRNM**) and duplicates deposited in the fungarium of the Natural History Museum in Paris, France (**PC**).

Taxon sampling, sequence data and phylogenetic analyses

Translation elongation factor 1-alpha (*tef*-1) sequence data were produced following Buyck et al. (2014) for the newly described species from dried materials: four

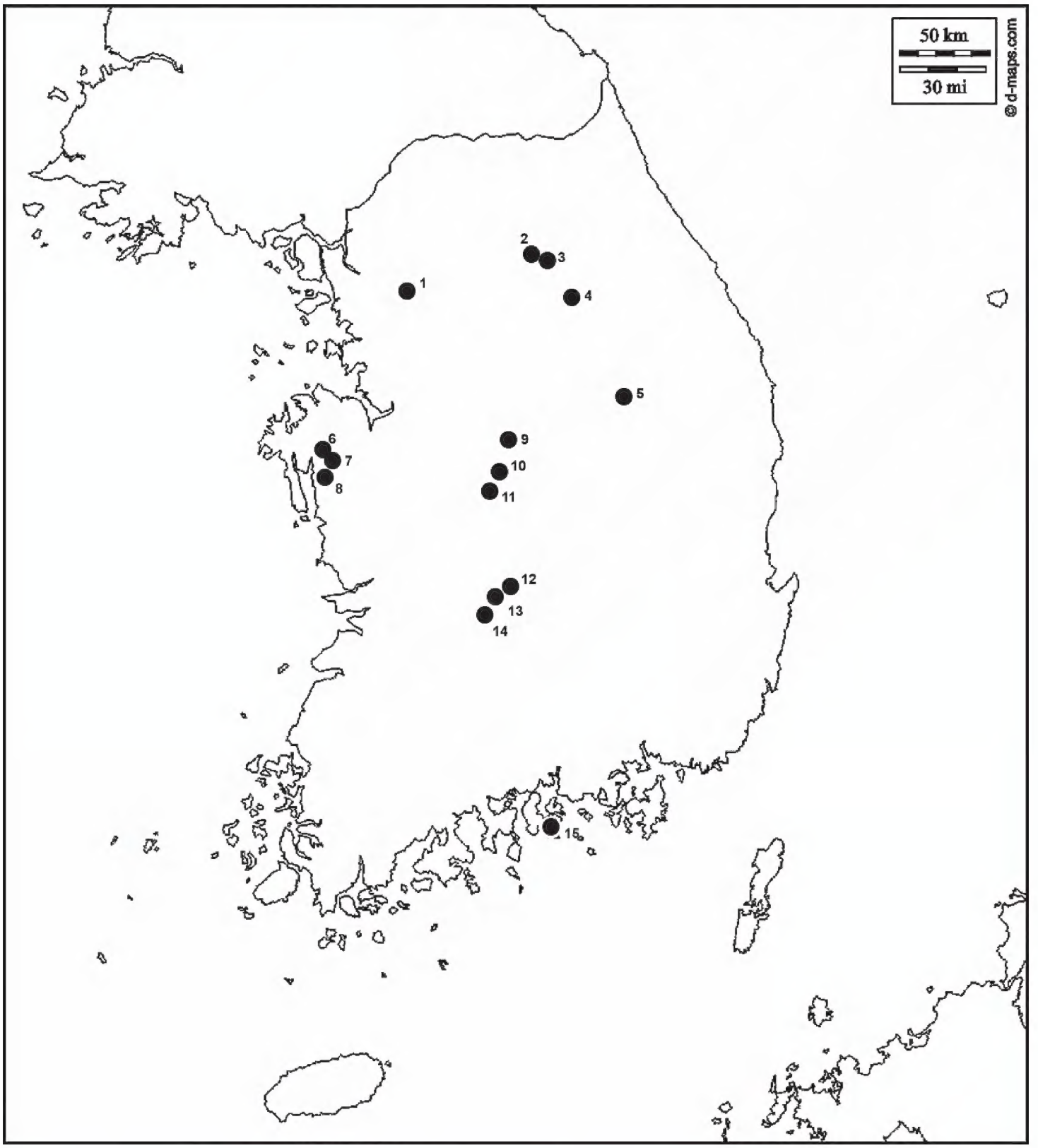

Figure 1. Map of localities of the *Cantharellus* species **1** Hongneung Arboretum, Seoul **2** Suta-sa, Dong-myeon, Hongcheon **3** Experimental Forest, Dong-myeon, Hongcheon **4** Mts. Chiaksan, Haggok-ri, Wonju **5** Guin-sa, Mts. Sobaek, Danyang **6** Yonghyeon National Natural Recreation Forest, Unsan-myeon, Seosan **7** Mts.Gaya, Deoksan-myeon, Yesan **8** Sudeok-sa, Deoksan-myeon, Yesan **9** Mt. Gunjusan, Chilseon-myeon, Goeisan **10** Cheoncheon-myeon, Geoisan **11** Songnisan National Park, Boeun **12** Mulan Valley, Sangcheon-myeon, Yeongdong **13** Minjoojisan Recreational Forest, Yonghwa-myeon, Yeongdong **14** Unjangsan Recreational Forest, Jeongcheon-myeon, Jinan **15** Pyunbaeg Recreational Forest, Samdong-myeon, Namhae.

sequences for four collections of *Cantharellus citrinus* sp. nov and one sequence from a collection of *C. curvatus* sp. nov. Additional *tef*-1 sequences were obtained for two previously described species: for two collections of *C. koreanus* Buyck, Antonín & V. Hofst. and for one collection of *C. albovenosus* Buyck, Antonín & V. Hofst. We

introduced these newly produced *tef*-1 sequences in the alignment obtained by Antonín et al. (2017). Species of subg. *Pseudocantharellus* Eyssart. & Buyck were used as outgroup sequences. GenBank submissions numbers are given in Fig. 2. Alignment of sequence data was performed manually in MacClade (Maddison and Maddison 2003). Three independent searches for the most likely tree were conducted in PhyML v. 3.0 (Guindon and Gascuel 2003) to check for convergence toward the same likelihood value. These searches used the GTR evolutionary model (Abadi et al. 2019) with the proportion of invariable sites, the gamma shape parameter and the number of substitution categories estimated during the search. Branches were considered as significantly supported when maximum likelihood bootstrap support (ML-bs) was ≥ 70%.

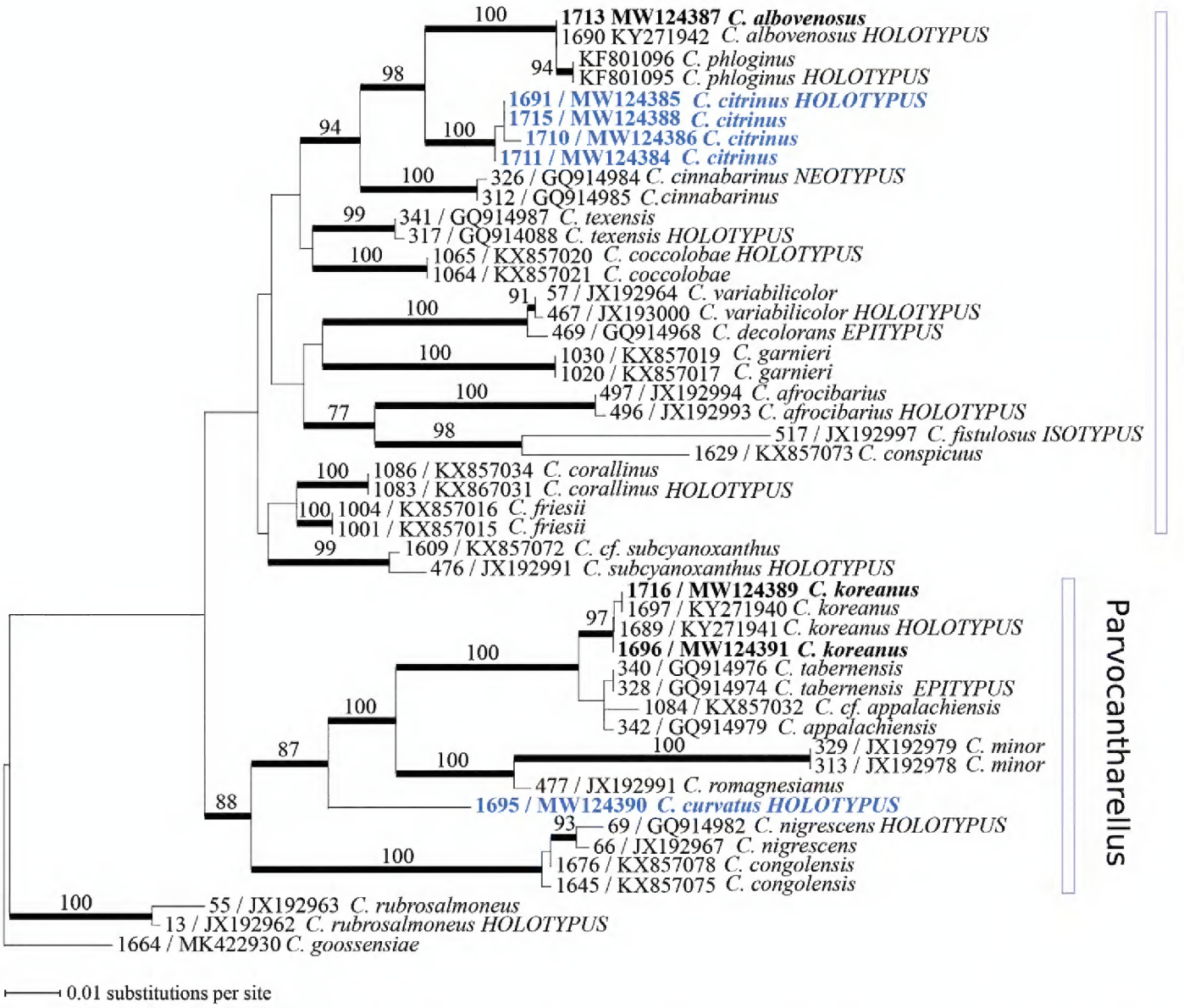
1713 MW124387 C. albovenosus
1690 KY271942 C. albovenosus HOLOTYPUS
KF801096 C. phloginus
KF801095 C. phloginus HOLOTYPUS
1691 / MW124385 C. citrinus HOLOTYPUS
1715 / MW124388 C. citrinus
1710 / MW124386 C. citrinus
1711 / MW124384 C. citrinus
326 / GQ914984 C. cinnabarinus NEOTYPUS
312 / GQ914985 C.cinnabarinus
341 / GQ914987 C. texensis
317 / GQ914088 C. texensis HOLOTYPUS
1065 / KX857020 C. coccolobae HOLOTYPUS
1064 / KX857021 C. coccolobae
57 / JX192964 C. variabilicolor
467 / JX193000 C. variabilicolor HOLOTYPUS
469 / GQ914968 C. decolorans EPITYPUS
1030 / KX857019 C. garnieri
1020 / KX857017 C. garnieri
497 / JX192994 C. afrocibarius
496 / JX192993 C. afrocibarius HOLOTYPUS
517 / JX192997 C. fistulosus ISOTYPUS
1629 / KX857073 C. conspicuus
1086 / KX857034 C. corallinus
1083 / KX867031 C. corallinus HOLOTYPUS
1004 / KX857016 C. friesii
1001 / KX857015 C. friesii
1609 / KX857072 C. cf. subcyanoxanthus
476 / JX192991 C. subcyanoxanthus HOLOTYPUS
1716 / MW124389 C. koreanus
1697 / KY271940 C. koreanus
1689 / KY271941 C. koreanus HOLOTYPUS
1696 / MW124391 C. koreanus
340 / GQ914976 C. tabernensis
328 / GQ914974 C. tabernensis EPITYPUS
1084 / KX857032 C. cf. appalachiensis
342 / GQ914979 C. appalachiensis
329 / JX192979 C. minor
313 / JX192978 C. minor
477 / JX192991 C. romagnesianus
1695 / MW124390 C. curvatus HOLOTYPUS
69 / GQ914982 C. nigrescens HOLOTYPUS
66 / JX192967 C. nigrescens
1676 / KX857078 C. congolensis
1645 / KX857075 C. congolensis
55 / JX192963 C. rubrosalmoneus
13 / JX192962 C. rubrosalmoneus HOLOTYPUS
1664 / MK422930 C. goossensiae
Cinnabarini
Parvocantharellus
0.01 substitutions per site

Figure 2. Most likely tree (-ln = 3254.82124) obtained by phylogenetic analyses of 48 *tef*-1 *Cantharellus* sequences. Supported branches are in bold with bootstrap values, when significant (≥ 70%), indicated along the branches. Sequences newly obtained for this study are in bold and highlighted in blue for the new species described in the present study. Extraction numbers and GenBank accession numbers for *tef*-1 sequences are reported before taxon names. Delimitation of *Cantharellus* subgenera *Cinnabarini* and *Parvocantharellus* (sensu lato) are indicated and *C. goossensiae* Heinem. and *C. rubrosalmoneus* (Buyck & V. Hofst.) Buyck & V. Hofst. (both in *C.* subg. *Pseudocantharellus*) are used as outgroup.

Results

Phylogeny

The final alignment of *tef*-1sequences included 837 characters. After the removal of three spliceosomal introns, the alignment used for phylogenetic analyses included 629 characters. The most likely tree (Fig. 2) suggests that *C. citrinus* sp. nov. is part of subgenus *Cinnabarini* Buyck & V. Hofst. This species has a sister relationship (ML-bs = 98%) with the subclade (ML-bs =100%) including *C. albovenosus* and *C. phloginus* S.C. Shao & P.G. Liu. Our phylogeny further suggests that *C. curvatus* sp. nov. nests in the significantly supported subgenus *Parvocantharellus* Eyssart. & Buyck (ML-bs = 88%). The new species occupies a basal position in a subclade (ML-bs = 87%) composed of *C. romagnesianus* Eyssart. & Buyck, *C. minor* Peck, *C. appalachiensis* R.H. Petersen, *C. tabernensis* Feibelman & Cibula and *C. koreanus* and is clearly separated (ML-bs = 100%) from these other species. The only other subclade (ML-bs 100%) in the subgenus is composed of the blackening *Cantharellus* from tropical Africa, *C. nigrescens* Buyck & V. Hofst. and *C. congolensis* Beeli.

Taxonomy

Cantharellus citrinus **Buyck, R. Ryoo & Antonín, sp. nov.**

MycoBank No: 837726

Figs 3, 4

Diagnosis. Differs from its closest Asian and North American relatives in the variously coloured but often bright lemon yellow pileus, similarly tinted stipe and smaller size, as well as in differences in sequence data produced for the transcription elongation factor (*tef*-1).

Holotype. South Korea. Geoi-san, Cheong-cheon-myeon, alt. 330 m, 36°37'02.99"N, 127°49'36.56"E, 14 Aug 2013, V. Antonín, R. Ryoo & K.-H. Ka, 1691 / VA 13.156 (holotype: BRNM 825748; isotype: PC 0142457).

Description. Basidiomata dispersed in small groups or fascicles. Pileus 4–20 mm broad, convex, with involute margin when young, then plane or infundibuliform with depressed centre and inflexed to straight, smooth margin, irregularly undulate when old, hygrophanous, finely tomentose when very young, soon glabrescent and smooth or slightly rugulose, uniformly coloured, light yellow, orange yellow to light orange (3–4A6, 4–5A5–7), sometimes with greyish yellow tinge when old. Hymenophore composed of thick vein-like folds, sometimes strongly decurrent in a reticulate pattern on upper stipe, often not reaching the pileus margin, forking or with rare lamellulae, transversely anastomosed in between, white to whitish (3A2); edges concolorous. Stipe 4–22 × 1–3(–4) mm, slightly tapering towards base when young, then cylindrical, sometimes curved, finely pubescent when young, later glabrescent, smooth, concolorous with pileus or slightly paler. Context thin, yellowish, fibrillose-hollow and yellow-

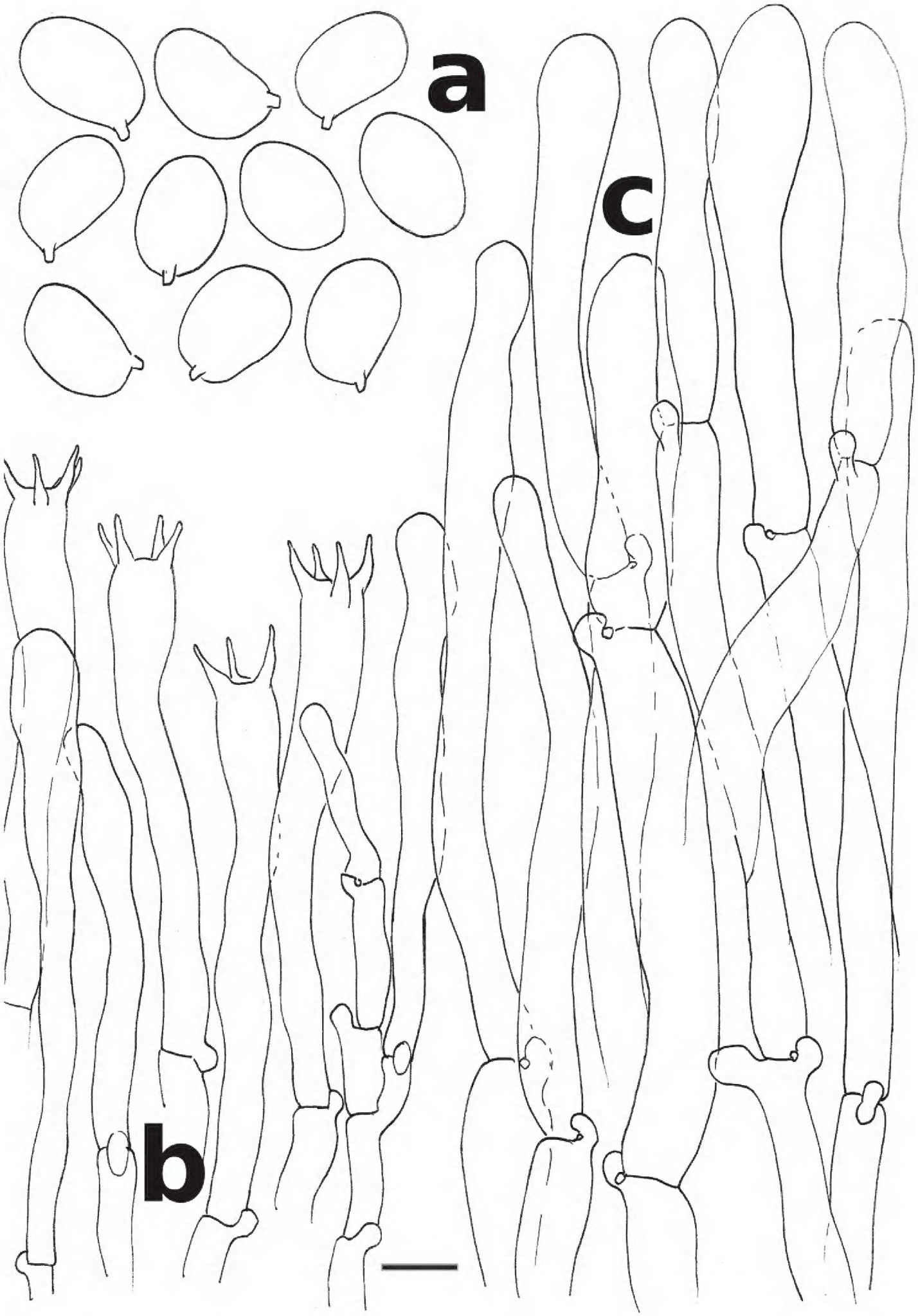

Figure 3. *Cantharellus citrinus* (holotype) **a** spores **b** basidia and basidiola **c** hyphal extremities of the pileipellis near mid-radius. Scale bar: 10 µm, but only 5 µm for spores. Drawings B. Buyck.

ish whitish in stipe when old, with a spicy apricot smell and mild taste. Spore print not obtained.

Basidiospores ellipsoid, (7.3–)7.6–**8.24**–8.4(–8.8) × (5.1–)5.4–**5.67**–5.9(–6.1) µm, Q = (1.32–)1.34–**1.42**–1.50(–1.56), smooth, thin-walled. Basidia mostly (42–)66–80 × 8 µm, 4–5(–6)-spored, narrowly clavate; basidiola subcylindrical and slender when young, undulate-wavy in outline, later becoming narrowly clavate, subfusoid, sometimes irregular, rarely submoniliform, thin-walled. Cystidia not observed. Subhymenium composed of narrow, filamentous and cylindrical cells. Pileipellis a cutis composed of cylindrical, ± thin-walled, smooth or minutely incrusted, sparsely septate, (4–)8–12 µm wide hyphae; terminal cells (36–)50–110 × 4.0–15 µm, appressed to suberect, mostly slightly clavate, some with a subapical weak constriction, obtuse, thin-walled. Stipitipellis a cutis of cylindrical, slightly thick-walled, 2.5–6.0(–7.0) µm wide hyphae with isolated terminal cells distinct only in a narrow zone at very top, otherwise rare to absent, 20–51 × 4.0–11 µm, (narrowly) clavate, cylindrical or subfusoid, thin-walled. Clamp connections everywhere and distinct.

Habitat. On soil near *Quercus mongolica* Fisch. ex Ledeb., *Q. acutissima* Carruth., *Quercus* sp., *Castanea crenata* Siebold & Zucc., *Carpinus laxiflora* (Siebold & Zucc.) Blume and *Abies koreana* E.H. Wilson.

Etymology. The name refers to the frequent bright lemon yellow colour of pileus and stipe surface of the most common form.

Other specimens examined. Jinan, Jeongcheon-myeon, Unjangsan Recreational Forest, alt. 390 m, 35°54'01.13"N, 127°24'59.41"E, 7 Sep 2016, V. Antonín, R. Ryoo, K.-H. Wang & Y.-S. Jang, 1710 / VA 16.169 (BRNM 825753, PC 0142467). Ibid., 1711 / VA 16.170 (BRNM 825754, PC 0142468). Yeongdong, Yonghwa-myeon, Minjoojisan Recreational Forest, alt. 540 m, 36°03'14.57"N, 127°49'43.15"E, 26 Aug 2015, V. Antonín, K.-H. Ka, K.S. Kim & J.A. Kang, 1715 / VA 15.93 (PC 0142472).

Remarks. The description is based on the type specimen, but examination of the other specimens shows that variation of morphological features includes a rather wide amplitude of the overall colour, which seems – based on identical *tef1* sequences – to extend from entirely and predominantly pale lemon yellow to an overall deep orange. Collection from Jinan (VA 16.169, BRNM 825753, PC 0142467) differs from other collections of this species by an orange (5–6A7) pileus, light yellow to light orange (4–5A5) lamellae and a stipe more or less concolorous with the pileus.

This new species is here placed in *Cantharellus* subg. *Cinnabarini* (Fig. 2), a subgenus that comprises several species exhibiting a similarly wide colour range, e.g. the Malagasy *C. variabilicolor* Buyck & V. Hofst. (in Ariyawansa et al. 2015) or the North American *C. cinnabarinus* (Schwein.) Schwein. *Cantharellus citrinus* is here shown to be part of a well-supported clade composed of two other Asian species, the Chinese *C. phloginus* and Korean *C. albovenosus*. The latter two species are very different in general aspect, but, except for a single mutation in the coding part, the *tef*-1 sequences of both species are identical, even including the introns. Yet, their

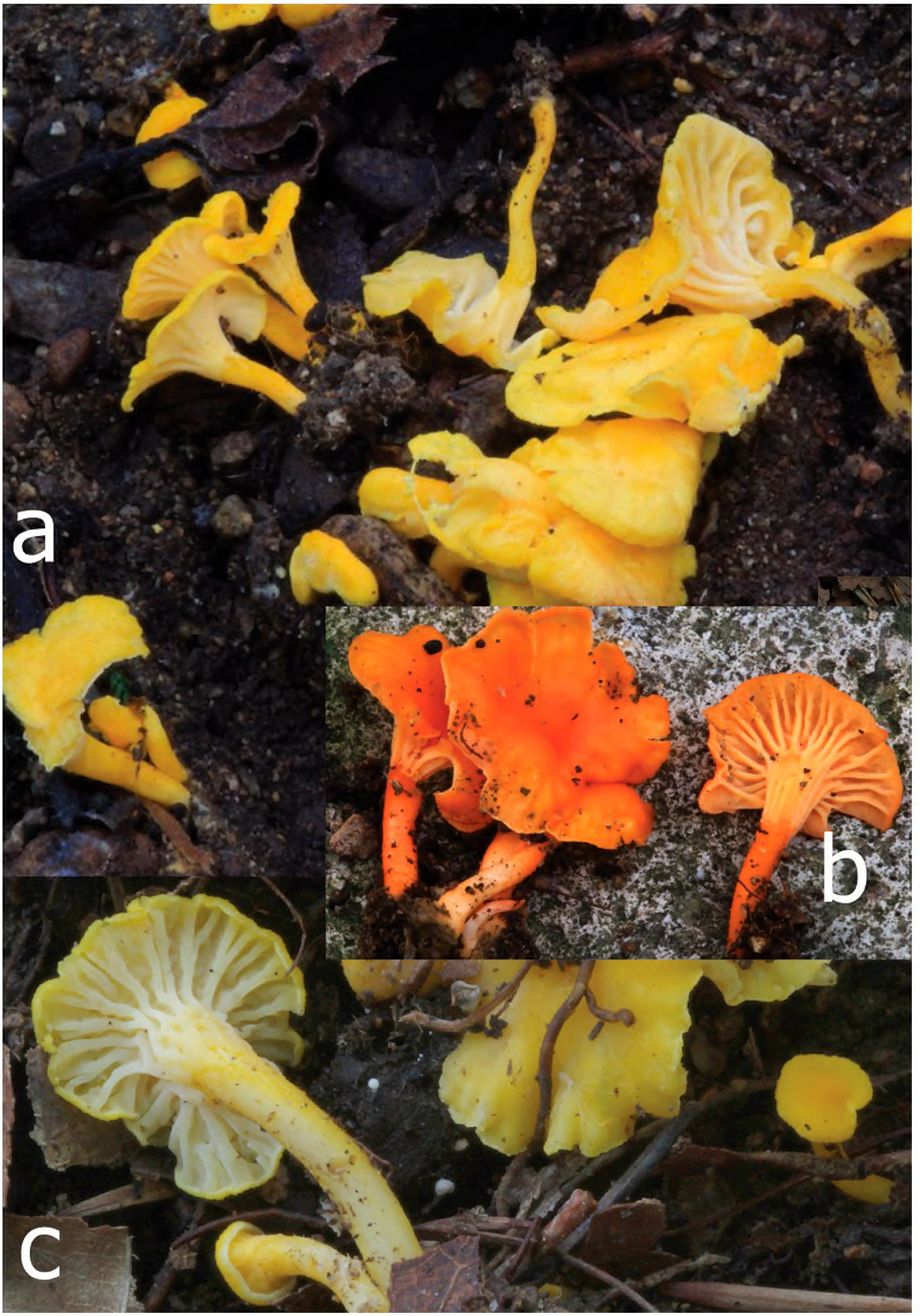

Figure 4. a–c *Cantharellus citrinus*, yellow, more common form **a** (VA 13.170) **b** *C. citrinus*, reddish orange form (VA 16.169) **c** (VA 13.156, holotype). Photos V. Antonín.

very different general habitus justifies us in our view that we should accept them as a separate species. The clade comprising these Asian species is sister to a clade composed of North American species.

Because of its very small overall size and comparable overall colour, *C. citrinus* could also easily be mistaken for some species in *Cantharellus* subg. *Parvocantharellus* Eyssart. & Buyck, in particular the European *C. romagnesianus* (= *C. pseudominimus* Eyssart. & Buyck, see Olariaga et al. 2015). Under the microscope, *C. citrinus* differs hardly from its Asian relatives and identification relies principally on field characters or sequence data.

***Cantharellus curvatus* Buyck, R. Ryoo & Antonín, sp. nov.**
MycoBank No: 837727
Figs 5, 6

Diagnosis. Differs from the European *C. romagnesianus* in the distinctly smaller spores and shorter basidia (see Olariaga et al. 2016), the strongly veined hymenophore and sequence data obtained from the transcription elongation factor one alpha (*tef-1*).

Holotype. South Korea. Yesan, Deoksan-myeon, Sudeok-sa, alt. 220 m, 36°39'57.40"N, 126°37'20.91"E, 8 Jul 2014, V. Antonín & K.-H. Ka, 1695 / VA 14.57 (holotype: BRNM 825749; isotype: PC0142461)

Description. Basidiomata in groups. Pileus 20–30 mm broad, low convex with a low broad central umbo and involute margin, then irregularly applanate or shallowly infundibuliform with an undulate, often uplifted margin, hygrophanous, not translucently striate, smooth, glabrous, watery dull yellow when moist, drying out to orangish yellow (± slightly more yellow than 4A5). Hymenophore composed of distant gill folds [L = 37–40], shortly decurrent, thick, sometimes furcate when young, furcate-anastomosed in upper half when old, pale yellow (± 3A3), ± dirty (greyish) yellow at the end; edge concolorous. Stipe 25–30 × 3.5–4 mm, cylindrical and tapering towards base, longitudinally fibrillose, yellow (± concolorous with pileus). Context pale whitish-yellowish, with cantharelloid smell.

Basidiospores (7.25–)7.5–**8.05**–9.0 × 5.0–**5.25**–6.0(–6.25) µm, Q =1.40–**1.52**–1.66, ellipsoid, rarely broadly ellipsoid, ventrical applanate or suballantoid, thin-walled, smooth. Basidia 42–55 × 9.5–12 µm, (4–)6-spored, narrowly clavate, clamped. Basidiola 15–42 × 3.0–11 µm, clavate, cylindrical, subfusoid, irregularly curved or undulate. Trama hyphae of cylindrical to fusoid, clamped, ± thin-walled, 4.0–20 µm wide cells. Pileipellis a cutis composed of cylindrical, clamped, mostly thin-walled, 4.0–10 µm wide hyphae; terminal cells appressed to suberect, mostly cylindrical, slightly thick-walled, up to 80 µm long and 5.0–10(–15) µm wide. Stipitipellis a cutis of cylindrical, parallel, slightly thick-walled, clamped, 3.0–6.0 µm wide hyphae. Terminal cells appressed to suberect, clavate or cylindrical.

Habitat. On soil under *Pinus densiflora* Siebold & Zucc. and *Castanea crenata*.

Figure 5. *Cantharellus curvatus* (VA 14.57, holotype). Scale bar: 15 mm. Photos V. Antonín.

Etymology. Referring to the curved-undulate hymenial cells, viz. basidia and particularly basidiola.

Remarks. This Asian species differs from the European *C. romagnesianus*, presently the most similar chanterelle, in the distinctly smaller spores and shorter basidia (see Olariaga et al. 2016), further also in the strongly anastomosing hymenophore and in sequence data obtained from the transcription elongation factor one alpha (*tef-1*).

***Cantharellus anzutake* W. Ogawa, N. Endo, M. Fukada & A. Yamada, Mycoscience 59(2): 158 (2018)**

Figs 7–9

Description. Pileus 10–40 mm broad, convex-conical when young, soon plane to broadly funnel-shaped, sometimes with a low obtuse umbo at centre, margin involute then inflexed to straight and undulate, pruinose when young then ± glabrous, greasy when moist, smooth or slightly uneven, not translucently striate, yellow (4A7–8), sometimes with darker ("dirty") centre. Lamellae moderately close, L = c. 25–30, decurrent, often furcate, rarely branched, whitish to pale cream from ± half radius toward the stipe attachment, then yellow towards pileus margin. Stipe 20–40 × 3.5–6 mm, cylindrical, not broadened towards base, finely pruinose when young, then glabrous, white, not hollowing. Context yellow beneath pileipellis, white otherwise. Smell slight, cantharelloid. Taste mild with slightly sharp aftertaste. Spore print not obtained.

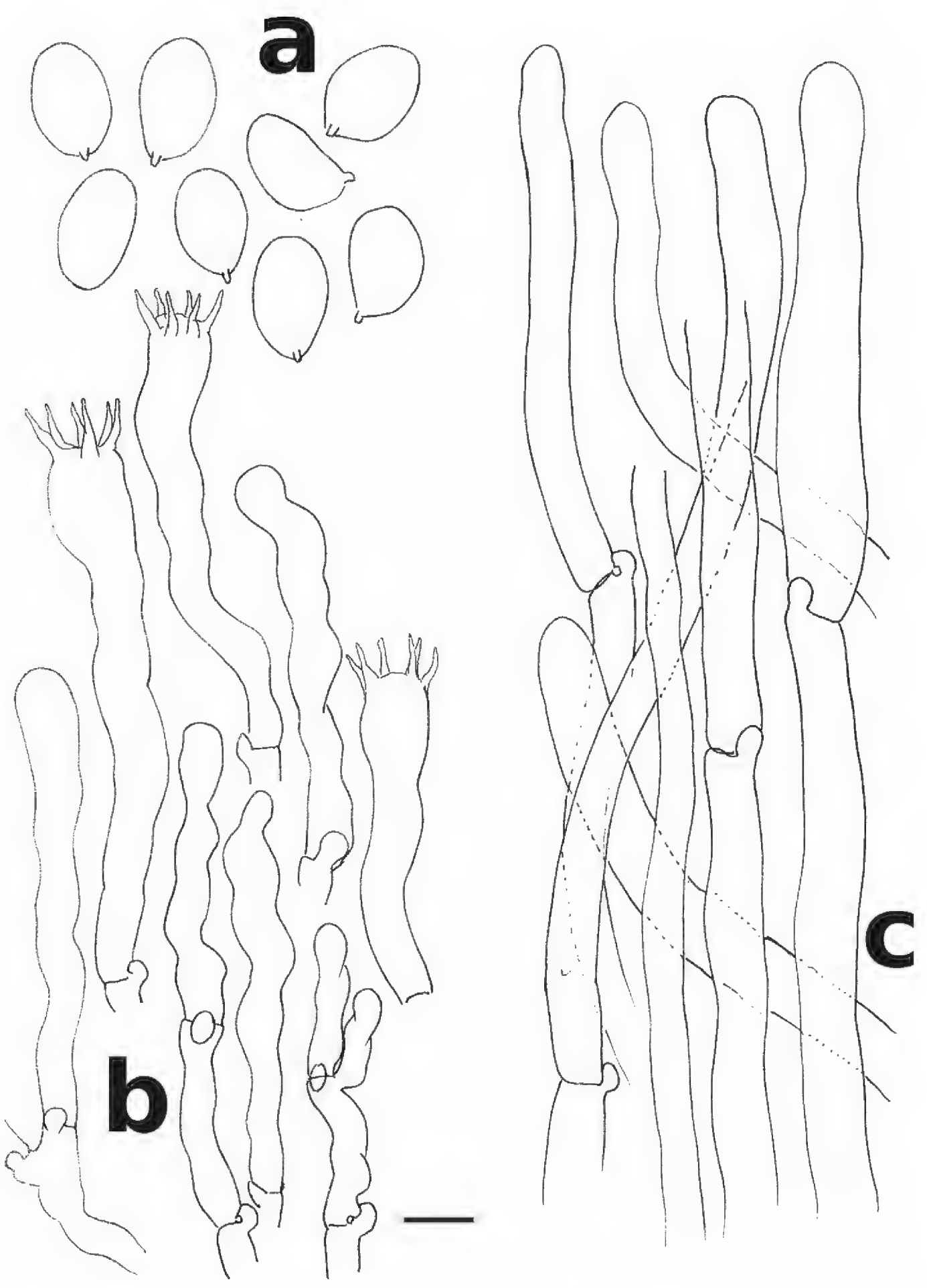

Figure 6. *Cantharellus curvatus* (holotype) **a** spores **b** basidia and basidiola **c** hyphal extremities of the pileipellis near mid-radius. Scale bar: 10 µm, but only 5 µm for spores. Drawings B. Buyck.

Basidiospores ellipsoid to ovoid, (6.9–)7.2–**7.56**–8.0(–8.3) × (4.6–)4.8–**5.10**–5.4(–5.6) µm, Q = (1.31–)1.39–**1.49**–1.58(–1.68), smooth, with a small apiculus. Basidia clavate-pedicellate, (60–)70–80 × 7–8 µm, long and slender, mostly 6(–5)-spored

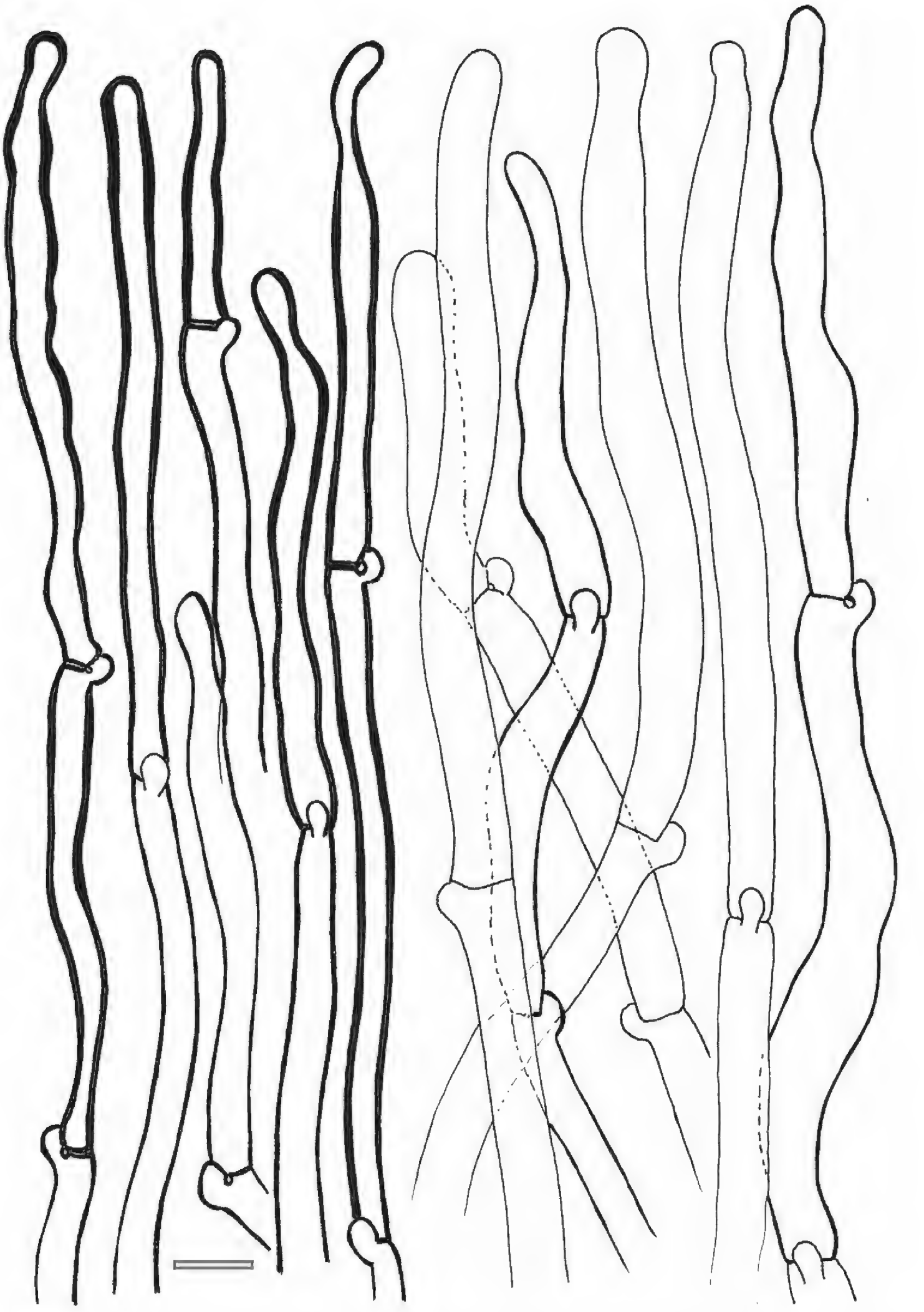

Figure 7. *Cantharellus anzutake*, microscopic features. Hyphal extremities at the pileus surface, on the left near the pileus center, on the right closer to the pileus margin. Scale bar: 10 µm. Drawings B. Buyck.

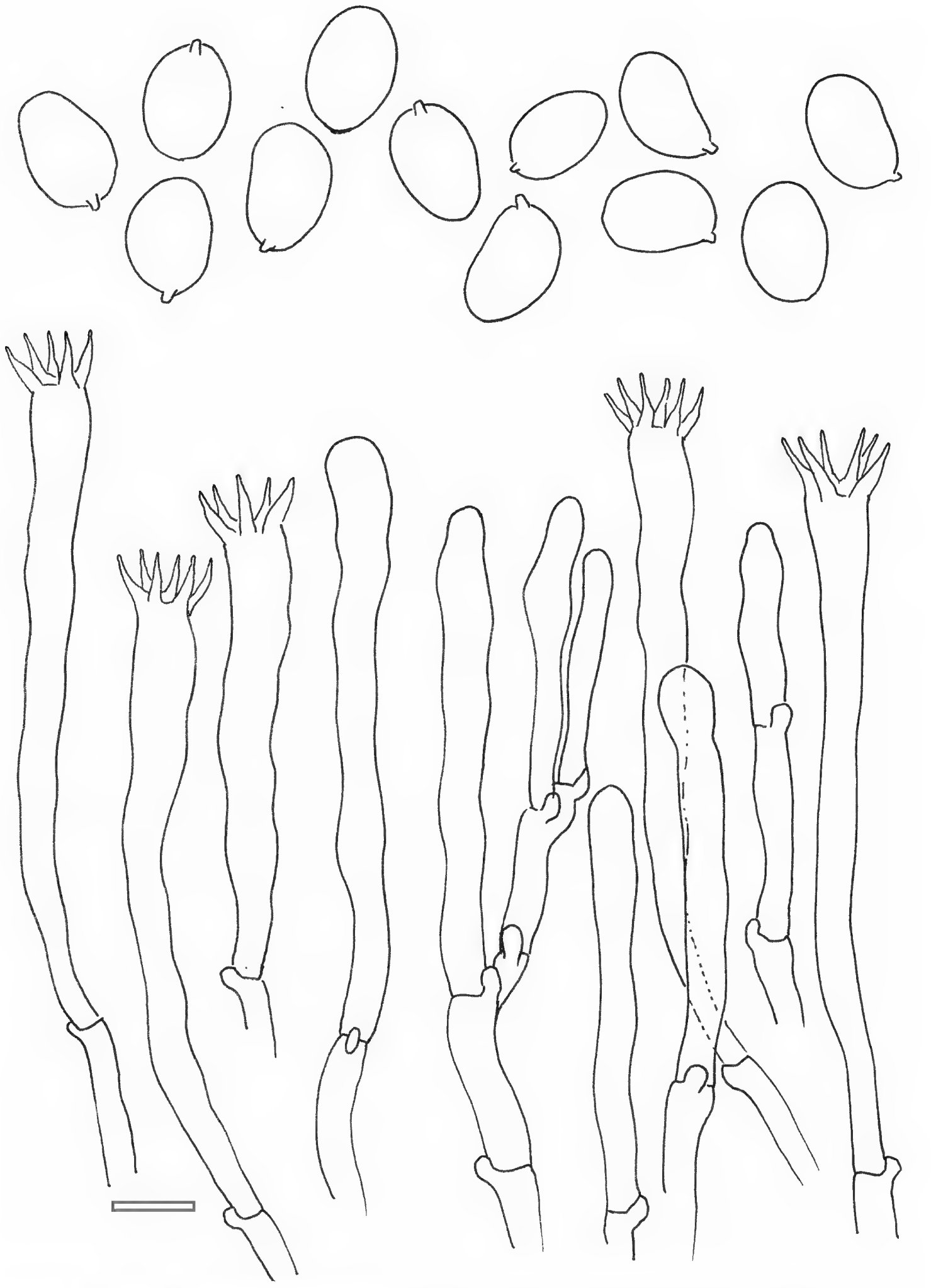

Figure 8. *Cantharellus anzutake*. Microscopic features. Basidia, basidiola and spores. Scale bar: 10 µm, but only 5 µm for spores. Drawings B. Buyck.

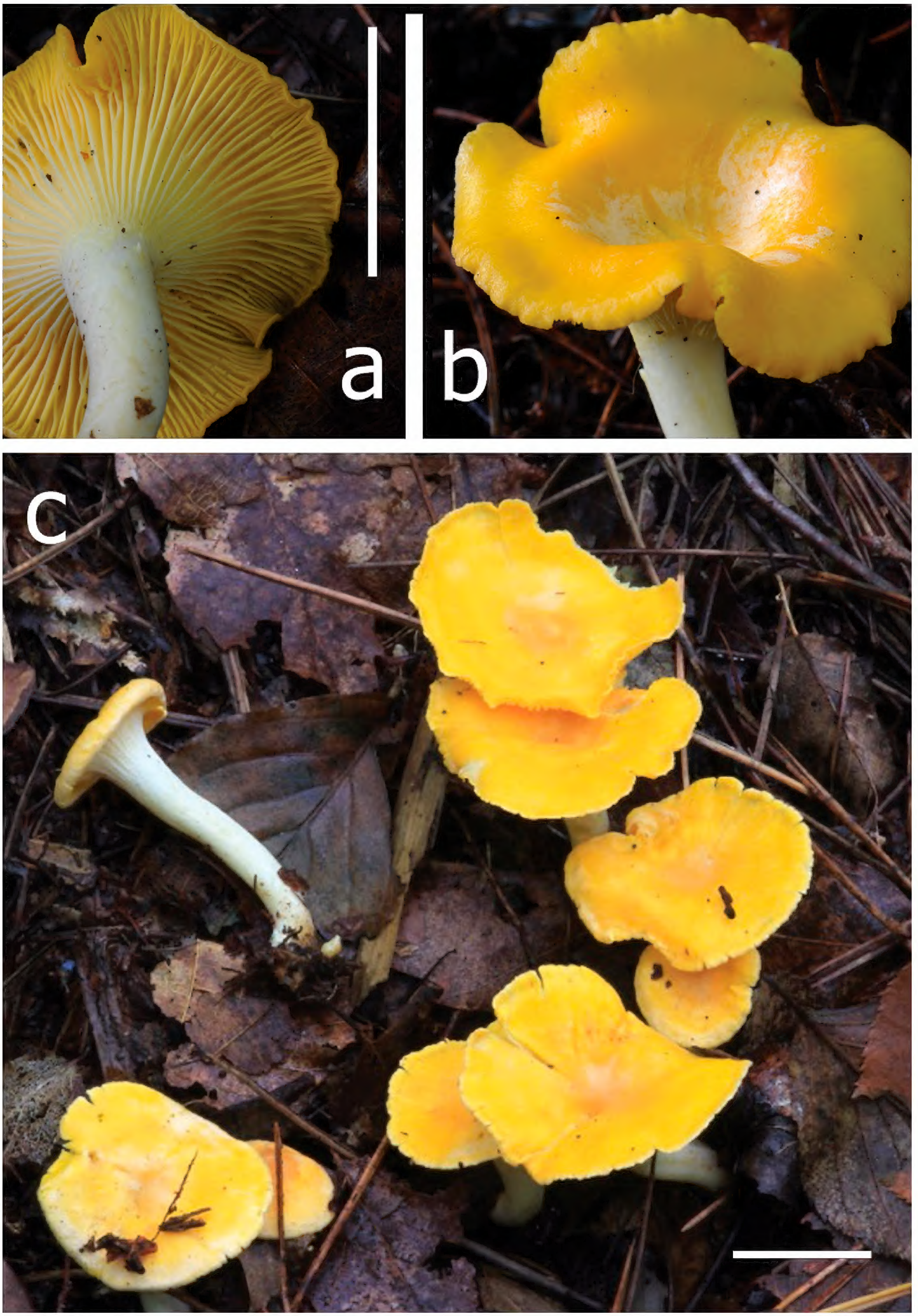

Figure 9. *Cantharellus anzutake* **a, b** Ka & Ryoo 3_Korea_1-2 [22/08/2012, Pyeongchang, Jungwangsan, 37°27'27.48"N, 128°29'04.35"E, 771 m asl, under *Pinus koraiensis* Siebold & Zucc.] **c** Antonín 16.140 (PC0142465). Note the very pale hymenophore in young specimens, remaining for a long time paler closer to the stipe when maturing. Scale bar: 20 mm.

with stout sterigmata. Subhymenium filamentous, composed of long and slender, cylindrical cells of similar diam. as the basidium base. Cystidia none. Pileipellis a loose tissue of intricately intertwining, sparsely septate, long and slender hyphal ends, near the pileus margin often aggregated in long tufts; hyphal ends composed of long, cylindrical, 5–8(–12) µm diam. cells, with refringent, thin- to slightly thickened walls, but in the pileus centre more frequently thick-walled; the terminal cell slender, toward the pileus margin (40–)60–130 µm long, obtuse rounded at the tip, cylindrical, hardly differentiated from subapical ones; in the pileus centre often somewhat irregularly constricted near the tip, but never very strongly so, and usually shorter, 30–100 µm, and on average somewhat narrower.

Habitat. On soil under *Pinus densiflora*, *Carpinus laxiflora* and *Quercus mongolica*.

Specimens examined. Jinan, Jeongcheon-myeon, Unjangsan Recreational Forest, 35°54'05.55"N, 127°24'53.89"E, alt. 400 m, 31 Aug 2016, V. Antonín, K.-H. Ka & S.-H. Kim, 1708 / VA 16.140 (BRNM 825751, PC 0142465). Ibid., VA 16.142 (BRNM 825752, PC 0142466).

Remarks. This species is a typical member of *Cantharellus* subg. *Cantharellus*, and belongs to a group that is often referred to as the 'golden chanterelles' or the *C. cibarius* Fr. complex, representing the commercially most important chanterelles on the international market. This species complex is reputedly very difficult to identify, in particular because of the very variable field aspect of the various species involved (Olariaga et al. 2015, 2016). Hence, positive identification frequently requires molecular sequence data. Our identification is here based on the high quality ITS sequence we obtained for VA 16.142 and which is identical to the one deposited for the *C. anzutake* holotype (GenBank LC085359, similarity 100% for 100% coverage); both these ITS differ from other yellow species of chanterelles described from Asia by a ca 100 bp deletion in the ITS1 region (Ogawa et al. 2018).

Because of the whitish hymenophore when young and the sometimes deep orange-yellow to cinnamon buff pileus surface, this species may be somewhat reminiscent of *C. albovenosus*. The latter species, however, has always a much brighter orange pileus and a more veined hymenophore that remains white, even with age, and it belongs in subgenus *Cinnabarini* (see Antonín et al. 2017). It is interesting to note that both Japanese and Korean specimens were collected near *Pinus densiflora* among possible host trees.

Acknowledgements

V. Antonín is collaborating with South-Korean mycologists on various taxonomic projects since 2007. His collection trips to South Korea were supported by project FP 0801-2010-01 and FP0801-2018-01 of the National Institute of Forest Science in South Korea, and his laboratory studies were funded through the institutional support of long-term conceptual development of research institutions provided by the Ministry of Culture (ref. MK000094862).

References

Abadi S, Azouri D, Pupko T, Mayrose I (2019) Model selection may not be a mandatory step for phylogeny reconstruction. Nature Communications 10: e934. https://doi.org/10.1038/s41467-019-08822-w

An DY, Liang ZQ, Jiang S, Su MS, Zeng NK (2017) *Cantharellus hainanensis*, a new species with a smooth hymenophore from tropical China. Mycoscience 58(6): 438–444. https://doi.org/10.1016/j.myc.2017.06.004

Antonín V, Hofstetter V, Ryoo R, Ka K-H, Buyck B (2017) New *Cantharellus* species from the Republic of Korea. Mycological Progress 16(8): 753–759. https://doi.org/10.1007/s11557-017-1312-2

Ariyawansa HA, Hyde KD, Jayasiri SC, Buyck B, Chethana, KWT, Dai DQ, Dai YC, Daranagama DA, Jayawardena RS, Lücking R, Ghobad-Nejhad M, Niskanen T, Thambugala KM, Voigt K, Zhao RL, Li GJ, Doilom M, Boonmee S, Yang ZL, Cai Q, Cui YY, Bahkali AH, Chen J, Cui BK, Chen JJ, Dayarathne MC, Dissanayake AJ, Ekanayaka AH, Hashimoto A, Hongsanan S, Jones EBG, Larsson E, Li WJ, Li QR, Liu JK, Luo ZL, Maharachchikumbura SSN, Mapook A, McKenzie EHC, Norphanphoun C, Konta S, Pang KL, Perera RH, Phookamsak R, Phukhamsakda C, Pinruan U, Randrianjohany E, Singtripop C, Tanaka K, Tian CM, Tibpromma S, Abdel-Wahab MA, Wanasinghe DN, Wijayawardene NN, Zhang JF, Zhang H, Abdel-Aziz FA, Wedin M, Westberg M, Ammirati JF, Bulgakov TS, Lima DX, Callaghan TM, Callac P, Chang CH, Coca LF, Dal-Forno M, Dollhofer V, Fliegerová K, Greiner K, Griffith GW, Ho HM, Hofstetter V, Jeewon R, Kang JC, Wen TC, Kirk PM, Kytövuori I, Lawrey JD, Xing J, Li H, Liu ZY, Liu XZ, Liimatainen K, Lumbsch HT, Matsumura M, Moncada B, Nuankaew S, Parnmen S, Santiago A, Sommai S, Song Y, Souza CAF, Souza-Motta CM, Su HY, Suetrong S, Wang Y, Wei SF, Yuan HS, Zhou LW, Réblová M, Fournier J, Camporesi E, Luangsa-ard JJ, Tasanathai K, Khonsanit A, Thanakitpipattana D, Somrithipol S, Diederich P, Millanes AM, Common RS, Stadler M, Yan JY, Li XH, Eberhardt U, Simonini G, Wen HA, Chen XH (2015) Fungal diversity notes 111–252: taxonomic and phylogenetic contributions to fungal taxa. Fungal Diversity 75: 27–274. https://doi.org/10.1007/s13225-015-0346-5

Buyck B, Antonín V, Chakraborty D, Baghela A, Das K, Hofstetter V (2018) *Cantharellus* sect. *Amethystini* in Asia. Mycological Progress 17: 917–924. https://doi.org/10.1007/s11557-018-1403-8

Buyck B, Kauff F, Eyssartier G, Couloux A, Hofstetter V (2014) A multilocus phylogeny for worldwide *Cantharellus* (Cantharellales, Agaricomycetidae). Fungal Diversity 64: 101–121. https://doi.org/10.1007/s13225-013-0272-3

Corner EJH (1966) A monograph of cantharelloid fungi. Annals of Botany Memoirs 2: 1–255.

Das K, Hofstetter V, Chakraborty D, Baghela A, Singh SK, Buyck B (2015) *Cantharellus sikkimensis* sp. nov. (Cantharellales, Agaricomycetes) from the Indian Himalayas. Phytotaxa 222(4): 267–275. https://doi.org/10.11646/phytotaxa.222.4.4

Eyssartier G, Stubbe D, Walleyn R, Verbeken A (2009) New records of *Cantharellus* species (Basidiomycota, Cantharellaceae) from Malaysian dipterocarp rainforest. Fungal Diversity 36: 57–67.

Guindon S, Gascuel O (2003) A simple, fast, and accurate algorithm to estimate large phylogenies by maximum likelihood. Systematic Biology 52: 696–704. https://doi.org/10.1080/10635150390235520

Kim Y-S (2004) The mushrooms of Korea. National Institute of Agricultural Science and Technology, Suwon, 467 pp.

Kim YP, Seok S-J, Kim WK, Won HY, Lee KH (2006) The mushrooms of Halla Mountain. Jeju Special Self-Governing Province Agricultural Research and Extension Service, 317 pp.

Kornerup A, Wanscher JH (1983) Methuen handbook of colour (3rd edn.). Eyre Methuen, London, 252 pp.

Kumari D, Upadhyay RC, Reddy MS (2011) *Cantharellus pseudoformosus*, a new species associated with *Cedrus deodara* from India. Mycoscience 52: 147–151. https://doi.org/10.1007/S10267-010-0080-5

Kumari D, Upadhyay RC, Reddy MS (2013) New records of *Cantharellus* species from the northwestern Himalayas of India. Mycology 4(4): 205–220. https://doi.org/10.1080/21501203.2013.872205

Lee T-S (2011) Rearrangement list of Korean recorded mushrooms. Josoop Publishing Co., Seoul, 87 pp.

Ogawa W, Endo N, Fukuda M, Yamada A (2018) Phylogenetic analyses of Japanese golden chanterelles and a new species description, *Cantharellus anzutake* sp. nov. Mycoscience 59(2): 153–165. https://doi.org/10.1016/j.myc.2017.08.014

Olariaga I, Buyck B, Esteve-Raventos F, Hofstetter V, Manjon JL, Moreno G, Salcedo I (2015) Assessing the taxonomic identity of white and orange specimens of *Cantharellus*: occasional colour variants or independent species? Cryptogamie Mycologie 36(3): 287–300. https://doi.org/10.7872/crym/v36.iss3.2015.287

Olariaga I, Moreno G, Manjoni J-L, Salcedo I, Rodriguez D, Hofstetter V, Buyck B (2016) *Cantharellus* (Cantharellales, Basidiomycota) revisited in Europe through a multigene phylogeny. Fungal Diversity 83(1): 263–292. https://doi.org/10.1007/s13225-016-0376-7

Park WH, Lee HD (1991) Wild fungi of Korea. Kyo-Hak Publishing Co., Seoul, 508 pp.

Shao SC, Buyck B, Hofstetter V, Tian XF, Geng YH, Yu FQ, Liu PG (2014) *Cantharellus hygrophorus*, a new species in subgenus *Afrocantharellus* from tropical southwestern China. Cryptogamie Mycologie 35(3): 281–289. https://doi.org/10.7872/crym.v35.iss3.2014.283

Shao SC, Buyck B, Tian XF, Liu PG, Geng YH (2016a) *Cantharellus phloginus*, a new pink-colored species from southwestern China. Mycoscience 57: 144–149. https://doi.org/10.1016/j.myc.2015.12.004

Shao SC, Liu PG, Tian XF, Buyck B, Geng YH (2016b) A new species of *Cantharellus* (Cantharellales) from subalpine forest in Shangri-la, Yunnan, China. Phytotaxa 252(4): 273–279. https://doi.org/10.11646/phytotaxa.252.4.3

Shao SC, Tian XF, Liu PG (2011) *Cantharellus* in southwestern China: a new species and a new record. Mycotaxon 116: 437–446. https://doi.org/10.5248/116.437

Suhara H, Kurogi S (2015) *Cantharellus cyphelloides* sp. nov., an unusual *Cantharellus* species from the evergreen broad-leaved forest of Japan. Mycological Progress 14: 1–7. https://doi.org/10.1007/s11557-015-1079-2

Tian XF, Buyck B, Shao SC, Liu PG, Fang Y (2012) *Cantharellus zanghii*, a new subalpine basidiomycete from southwestern China. Mycotaxon 120: 99–103. https://doi.org/10.5248/120.99